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HETERŒCIOUS RUST-FUNGI.

Die Wirtswechselnden Rost-pilze. By H. Klebahn.
Pp. 426 + preface, appendix, bibliography, and two indexes. (Berlin: Bornträger, 1904.) Price 20 marks.

IN 1864-65 De Bary startled the biological world with his discovery of the heterœcism of the Uredineæ—with his proofs that the long suspected and often reiterated connection between the peculiar yellow fungus known as *Æcidium*, growing on the barberry, and the well-known rust-fungus, *Puccinia*, which devastates wheat and other cereals, is true in fact, and that the winter-spores of the latter germinate in spring and develop spores which infect the young barberry leaves, whereon are then developed the quite different spores of the *Æcidium*, which in their turn re-infect the wheat.

Investigations along the same experimental lines, and supported by the same irresistible logic, soon showed that many other Uredineæ, or rust-fungi, are capable of a similar change of life as they pass from one host-plant to another, among which were the Gymnosporangia of junipers, which develop the very different *Ræstelia* on Pomaceæ (hawthorns, pears, &c.), and the even more remarkable cases of *Coleosporium* on *Senecio*, which infects pines and develops thereon the curious æcidial forms known as pine blisters, or *Peridermium*.

The list of heterœcious Uredineæ, or rust-fungi, which thus change their hosts and develop a different kind of fungus on each host now numbers 160, including a few cases only where the phenomenon is not yet proved with absolute certainty by the experimental infections, and Klebahn has set himself the task of bringing together all the salient biological features of these remarkable plants, the economic importance of which to mankind is sufficiently indicated by the fact that the ravages of these parasites on our cereals and fodder plants, to say nothing of plants grown for pleasure, amount to many millions sterling every year, and that entire planting enterprises have been ruined by them.

But the subject of heterœcism has equally important bearings on the scientific philosophy of plant life, closely bound up as it is with the large questions of parasitism, and the nature and origin of species.

Klebahn's book is divided into two parts. The first 204 pages are concerned with the general aspects and discussions of the whole subject, the rest of the work with the special description and biology of each species in succession.

A mere enumeration of the headings suffices to show how interesting and important are the themes discussed in part i. Beginning with definitions and the history of the whole question of heterœcism, and a summary of the principal types of rust-fungi concerned, the author passes, in section iv., to an account of the means of distribution, and the conditions of germination and infection of the various kinds of spores produced by these remarkable fungi.

Certain controversial questions are then examined and answered. Klebahn emphatically declares (p. 43) that no evidence of value exists to show that the host which bears teleutospores can be infected by sporidia. He also examines the question of the necessity of heterœcism, and concludes that for some forms it is indispensable, though there are many which are known to be able to do without it. Some of the latter have a perennial mycelium, the classical example being De Bary's *Æcidium elatinum*, which induces the witches' brooms on silver firs.

By far the most exciting part of Klebahn's general exposition is that which deals with the wheat-rust problem and Eriksson's mycoplasma hypothesis. The wheat-rusts are held to be heterœcious, but able to dispense with the change of hosts. The wintering of uredo-spores is not regarded as sufficient to explain the infection of plants in the spring. But if the æcidium form is absent, and no uredo-spores have survived the winter, how is it the cereal shows infection next spring?

Klebahn insists on the importance of the world-wide distribution, in vast quantities, of the rust and of wheat culture, and that the wind can carry the spores, as it can far heavier particles such as grains of dust, hundreds of miles at a stretch, and Marshall Ward's experiments with the uredo-spores of *Puccinia dispersa* prove that such spores may retain their germinating power for sixty-one days.

Eriksson has entirely failed to grasp the significance of these facts, and his hypothesis of a latent and undiscoverable mycoplasma is not only superfluous, but has entirely broken down under the criticism of Marshall Ward's investigations, which show that the so-called incipient mycelia proceeding from "mycoplasma" are nothing but the normal haustoria of the fungus.

Section ix. deals with the distribution of rust-fungi and their passage into new regions. Section x. with methods, not only of culture and infection, but also—far too briefly—with the details of microscopic preparation. Section xi. is devoted to the problems of geographical areas of distribution, and contains much interesting information about the rusts of various countries.

In section xii. Klebahn illustrates, with ingenious diagram tables, the vagaries of these parasites in their choice of host-plants, and then passes to the discussion of the second of the two great burning questions of the rust problem, viz. the phenomenon of specialisation of parasitism, with which Eriksson's name must always be honourably associated.

Put shortly, the matter stands thus. Although a given species of rust-fungus is found on two host-species A and B, and although no trace of difference can be discovered with the microscope in the two cases, nevertheless the fungus on A will not infect B, nor will that on B infect A. This has been so abundantly and thoroughly proved by the researches of Eriksson, Klebahn, Marshall Ward and others that there can be no doubt as to the facts. The explanation appears to be that the fungus on A is so closely adapted to the physiological peculiarities of its host A that it cannot

suddenly alter its habits when placed on another host B to which it is not yet attuned, and consequently fails to infect B. But, as Marshall Ward showed, the host B may be merely a closely related variety of A, whence we must infer that the differences of food-material and so forth may be very small, and it is not surprising that occasionally a spore from A may succeed in infecting B, possibly when the latter is "off its guard," as it were, and short of its supplies of resistant materials or unduly lavish of its stores of attractive substances, or possibly because the spore in question happens to be better equipped than usual with the necessary solvents or poisons needed to break down the normal resistance of B. Be this as it may, once the fungus of A has gained a hold on B, it can now go on infecting B by means of its spores—it has now adapted itself to B.

But Marshall Ward showed that, while the fungus on A may fail to infect B, it may be readily able to infect a third related variety of host-plant C, and after adapting itself to C it may then pass easily to B; thus C becomes a bridging form from A to B.

Klebahn in sections xiv. and xv. discusses these matters, and the gradations of specific variation and their bearing on the theory of descent at great length, and concludes,

"The manifold characters of the existing biological species and races appear to have come into being owing to the alternating extensions and restrictions of the area of nutritive plants. These changes, and especially the restrictions of area, have been influenced by adaptation and selection, but many observations indicate that internal developmental tendencies, as yet entirely unexplained, have also played a part in determining the direction of the evolution."

Not much is gained by the latter phrase, but it at least shows the lines along which the thoughts of modern pathologists are tending.

Section xvi. deals with the question of the origin of heteroecism. Klebahn appears to doubt whether the increase of virulence said to be exhibited by *Æcidium* spores from barberry, as contrasted with uredo-spores grown on the wheat itself, can be maintained, and inclines to the belief that an advantageous utilisation of the periodic phenomena of vegetation is rather the key to the problem.

The author then proceeds to the discussion of pre-disposition, and accepts Marshall Ward's researches showing that anatomical peculiarities on the part of the host-plant do not explain it, concluding that in part chemical constitution, in part forces or factors of unknown nature in the protoplasm, are at the bottom of the question.

The concluding section of this part concerns the spermogonia, and views as to the alleged sexuality of the rust-fungi. The view is maintained that the spermatia are now functionless, and the author doubts the sexual character ascribed by Sappin-Trouffy and Dangeard to certain nuclear fusions in the development of teleutospores.

Part ii. is essentially a work of reference for investigators, and deals very thoroughly with all the special points in the biology of the various species of heteroecious Uredineæ raised by the Tulasnes, De Bary,

Dietel, Fischer, Magnus, Eriksson and Henning, Marshall Ward and other workers, including—by no means the least important—the author himself.

A very complete account is given of Eriksson's work on the rusts of the cereals, and of that of Marshall Ward on the brome rusts, and it is probably not too much to say that a more thorough and masterly work on the subject has never yet been produced.

That Klebahn's work will have a wide influence in furthering investigation into these extraordinary and important parasites cannot be doubted.

A STUDY OF RABIES.

Rabies: its Place among Germ-diseases and its Origin in the Animal Kingdom. By David Sime, M.D. Pp. xii+290. (Cambridge: University Press, 1903.) Price 10s. 6d. net.

THE admiration with which we must regard Pasteur's studies on rabies is increased by the fact that the actual microbe which causes the disease is unknown. Pasteur, nevertheless, by a logical application of the facts known concerning other pathogenic microbes, triumphed over this difficulty, and presented the world with a method of preventive inoculation against hydrophobia. He owed this achievement to the rigid and laborious series of experiments with which he was scrupulously careful to control his theories.

It is strange that Dr. Sime, with this example constantly before his eyes, should have been absolutely blind to its lesson. Anyone who seriously proposes to add to our knowledge of rabies must follow Pasteur's methods. No advance is likely to be made by the most ingenious reasoning unsupported by practical demonstration; we have no use at all nowadays for armchair pathology. Dr. Sime's work is beautifully printed and written in excellent English; it bears evidence of very wide reading and of careful though fanciful thought. But it is wordy to an exasperating degree, and the perpetual use of inverted commas and italics becomes almost a nightmare. There is no evidence from first to last that the writer has attempted to substantiate any one of the remarkable views which he sets forth by a single practical experiment.

There is room in the English language for a good monograph on rabies, but instead of giving a plain and straightforward account of what is at present known about the disease, which it is probable that Dr. Sime would have been competent to do, he presents us with a "study" of rabies from a number of theoretical standpoints, at times embroidered with excursions into transcendental bacteriology. It must suffice here to give a few examples only of the strange views supported by the author. The discussion as to the order of germ-diseases to which rabies belongs is based on a classification with which we are unfamiliar. Dr. Sime sharply divides infective diseases into two groups—those which protect against future attacks and those which do not; for these he employs the singularly unhappy names "prophylactic" and "preventive" respectively. Why a disease which does not protect should be called "preventive" is not